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APPLICATION OF MATHEMATICAL LEARNING THEORY AND LINGUISTICS TO SECOND-LANGUAGE LEARNING, WITH PARTICULAR REFERENCE TO RUSSIAN. FINAL REPORT.

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THE REPORT DESCRIBES THE DEVELOPMENT AND PROCEDURES OF A COMPUTER-BASED FIRST YEAR COURSE IN RUSSIAN VOCABULARY AND GRAMMAR, WHICH WILL BE INTRODUCED AT STANFORD IN SEPTEMBER 1967. THE FINAL EXAM WILL BE THE SAME FOR THE COMPUTER-BASED SECTIONS AS FOR THE CONVENTIONAL SECTIONS. THE PROGRAM IS BEING PRODUCED THROUGH THE JOINT EFFORTS OF THE PSYCHOLOGIST, LINGUIST-LANGUAGE TEACHER, NATIVE RUSSIAN INFORMANT, AND COMPUTER PROGRAMER ON THE PROJECT. THIRTY-FOUR OF THE PLANNED 100 LESSONS HAVE BEEN PREPARED. INSTALLATION OF TELETYPES AND TAPE RECORDERS IS IN PROGRESS. ALSO, AN EXPERIMENT IS BEING RUN TO DETERMINE THE FACTORS THAT INFLUENCE EASE OF LEARNING TO COMPREHEND RUSSIAN SPEECH. COMPREHENSION IS MEASURED EITHER BY ASKING THE STUDENT TO TRANSLATE THE UTTERANCE HE HEARD, OR TO ANSWER QUESTIONS BASED ON IT. ANALYSES WILL SEEK TO RELATE THE PROPORTION OF ERRORS TO SYNTACTIC AND PHONETIC PROPERTIES OF THE SPEECH, USING REGRESSION TECHNIQUES. FINALLY, A STUDY INVOLVING LEARNING OF JAPANESE-ENGLISH VOCABULARY PAIRS PERMITTED SPECIFICATION OF SOME OF THE LINGUISTIC DETERMINANTS OF DIFFICULTY IN LEARNING WORD-FOR-WORD TRANSLATIONS. INCLUDED IN THE APPENDIXES ARE (1) INSTRUCTIONS FOR LESSON PROGRAMERS ON PROGRAMING VOCABULARY ITEMS AND PRESENTING GRAMMATICAL RULES, AND (2) A DETAILED LIST OF THE CONTENTS TO BE COVERED IN EACH OF 30 LESSONS. (AUTHOR/SS)

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Application of Mathematical Learning Theory and Linguistics to Second-Language Learning

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and

Edward Crothers

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STANFORD UNIVERSITY

STANFORD, CALIFORNIA

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In order of importance, the three projects undertaken during the reporting year were I. Development of a computer-based course in beginning Russian, II. An experimental analysis of Russian speech comprehension, and III. A study of stimulus and response sources of difficulty in foreign-language vocabulary learning.

INTRODUCTION

I. Computer-based Russian course.

A program is being constructed to teach two sections (i.e., up to 36 students) of first-year Russian at Stanford, beginning in September 1967. In collaboration with the Slavic Division of the Department of Modern European Languages, the long-term objective is to convert first, second, and third year Russian courses to computerized instruction.

We will cover all the material contained in the Introductory Russian Grammar by Galina Stilman and William E. Harkins, published by Blaisdell Publishing Company in 1964, which the department of Modern European Languages uses in its first year Russian course. We will cover the same material as the conventional course on a quarter-by-quarter basis. However, the sequencing of material within the quarters will be our own, and we intend to include other vocabulary and grammar which the conventionally taught course does not cover.

It is obvious that the first version of such a course can offer only a tentative solution to a multitude of problems. In particular, a first version is unlikely to be maximally effective in two areas in which computer-based instruction possesses significant advantages over other approaches to teaching: (1) individualized response correction and (2) remedial instruction. It follows that the initial compilation of a course must be supplemented by an effort to improve the effectiveness of the course through the development of a more sophisticated approach to these areas. It will be the primary objective of this project to bring about such improvements.

A second objective would be the preparation of the preliminary version of a computer-based second-year Russian course. The attainment of this objective would require, in addition to the actual generation of the computer-based instructional material, an extensive preliminary effort to determine the proper content of such a course.

II. Russian speech comprehension experiment.

One of the fundamental requisites for mastery of a foreign language is the ability to comprehend a sentence spoken in that language. Although understanding can be measured in several ways, we chose to require the student either to select the proper English translation or to say whether the Russian utterance was true or false.

The objective is to isolate the factors responsible for making an item difficult.

III. Sources of difficulty in learning foreign-English vocabulary pairs.

A study by Rodgers using Japanese-English pairs extended his research of the previous project year, in which he conducted the same experiments but with Russian-English pairs. The rationale for these experiments is discussed on pp 1-5 of Progress Report No. 3, OE 6-14-009, dated July 1966.

METHOD

I. Computer-based Russian course.

Considerable attention has been devoted to designing the program, and consequently we are only now starting to run preliminary subjects and collect data. Hence, the main emphasis in this report will be on procedures.

The six teletypes ordered from the Teletype Corporation, Model 3S, have been received, installed, and are operational. Each has a Cyrillic alphabet set on the keyboard, and types in both Russian and English. In the second week of June, tape recorders were ordered from the Ampex Corporation. They are as follows:

Item	Qty.	Description
1	1 ea.	AG-440-2 in Console Mount 3-3/4 to 7-1/2 ips
2	1 ea.	AG-440-2, Rack Mounted 3-3/4 to 7-1/2 ips
3	5 ea.	AG-445-2, Rack Mounted 3-3/4 to 7-1/2 ips

Item 1 will be used for recording. Items 2 and 3 will be installed in the student stations. In addition, Item 2 will function as an auxiliary recording machine whenever the main recording machine is being serviced. All items will be installed and in operation well in advance of the fall quarter.

Preparatory to developing the major program, we did the following. (1) We reviewed a number of computer programs used in English, reading, and mathematics. Routines for presentation of drills and for evaluation of performance were found suitable for use in our own program. (2) We made a comprehensive index of the particular language skills taught in each quarter of the Stanford first-year Russian course. (3) We wrote a program to allow any desired word to be stored and delivered by the computer upon command.

A complete description of the lessons may be found in the "Instructions for Lesson Programmers," a copy of which also appears

in Appendix I. From this copy, we can summarize the main techniques controlling construction of the lessons. Principles 1-4 below deal with vocabulary and 5-9 with grammar.

1. Previously introduced words are periodically reviewed.
2. New vocabulary items are introduced within an already familiar grammar pattern.
3. A word is introduced by pronouncing it to the student. After he has attained partial mastery of sounds he learns to type the word on the teletype. Presence of the visual form now allows more advanced drill on pronunciation. Finally, the translation is introduced in a sentence context.
4. To build up skill in speech recognition, the student is given intensive drills in typing the Russian word or sentence which he hears. Later he progresses to lessons in which he hears a paragraph, followed by questions about the content. He types his answers on the teletype.
5. New grammar patterns are introduced using already familiar words.
6. Each grammar rule receives a large number of reinforced presentations.
7. Previously learned rules continue to receive attention after new rules are introduced.
8. When a new rule is being taught at first only a simple response is required (e.g., to say the preposition singular form). After that, the rule may appear in the context of a longer sentence or even a paragraph.
9. At the end of each lesson a complete review of all details of that lesson is given.

Thirty-four machine sessions of a planned 100 instructions have been outlined, and a copy of each outline appears in Appendix II. There will also be twenty review sessions. Each outline specifies the vocabulary and grammar to be covered in that particular lesson.

Briefly, the objective of lessons 1-30 is as follows:

Lesson No.

1. Introduces 5 stressed vowels, unstressed o=a; /t/ not aspirated; rising intonation for questions; no words for 'is', 'a', or 'the'.
2. No aspiration after /k/; palatalized consonants before /á/ and /é/; masc. and fem. past tense forms;
3. palatalized consonants before /ó/, /u/ and /i/; fem. acc.; palatalized consonants before other consonants and in final position; infinitive of verbs; masc. and fem. nom. of 'your' and 'our'; unstressed (e).
4. Pronunciation of /š́/ and /ž́/; /i/ after these sounds; /i/ after plain paired consonants; 'you' and 2. pl. present of verbs; 'we' and 1. pl. present of verbs; fem. acc. of 'our' and 'your'.

5. Masc. + fem. noun of 'my'; /j/ + /a/: fem. acc. of 'my'; /j/ + /u/; no aspiration after /p/; /j/ + /o/; /j/ + (e); /j/ + /i/; palatalized cons. + /j/ + vowel;

6. 'I' + 1.s. pres.; pron. of /x/; anim. acc. of masc. nouns; fem. of adjs.; unstressed (e) after /q/; acc. fem. of adjs.

7. Acc. of 'who'; masc. anim. acc. of adjs.; unstressed e after plain palatals; masc. anim. acc. also genitive form expressing possession; masc. anim.; acc. of 'your', 'our', 'my', devoicing of final voiced obstruents; ego - 'him, his';

8. velars before /i/; 3. pl. pres. of verbs, fem. genitive; 'but', acc. of pers. pronouns; cons. change in 1.s. pres. of type 'videt';

9. 'to have' construction; female correspondents to masc. nouns; u ne ←, u nego; 'them'; u nix; masc. anim. acc. of nouns in palatalized cons.; fem. gen. of nouns in velar; 'not to have'; 'what kind of'

10. 'what'; stress shift in 1.s. present; inanim. masc. acc.; prep. of nouns; 'ob' before vowels; masc. + fem. prep. of adjs.; 'in'; prep. of 'my', 'your', 'our', 'what', 'who'.

11. Prep. of personal pronouns; assimilation of v to following voweless consonant; labials replaced by labial + /l'/ in 1.s. pres.

12. reflexive possessive in 3. pers.; infinitive and 3. pl. established as basic forms; stress in 1. s. pres. related to infinitive stress.

13. Instrumental case of masc. nouns and adjs. in plain paired consonant, stressed after palatals and /c/, unstressed endings after sharp paired cons.

14. Masc. instr. of adjs. and possessives in velar or palatal; instr. of fem. nouns in plain paired cons.; fem. instr. of adjs.

15. Instr. of fems. in palatalized cons. of /j/; prep. of fems. in /ija/; instr. of unstressed masc. in palatalized cons.

16. Unstressed noun and adj. endings beginning with (o) after /č,š,ž,c/.

17. Instr. of pers. pronouns; instr. of 'what'; predicative instr.; past of byt'; preps. before 'me'

18. 'to seem'; future of 'to be'; future of imperfective verbs; 'how'; reflexive verbs.

19. Dat. case nouns; adjs.; possessives, 'who'; k + dative; 'to study' + dat.

20. dat. of pers. pronouns and 'what'; 'to help' with dative; impers. construction with dative; neuter nouns in nonpalatalized paired consonants; neuter nom. -acc. of adjs. in velars or plain paired cons.

21. Neuter nom. -acc. of possessives; same of stressed adj. stems in palatal cons.; neuters in /j/; imperative of /aj/ verbs.

22. Masc. in /a/;'to fear' with genitive; double negatives; imperative of stems in a stressed vowel; imperative of unstressed items in a vowel.

23. Imperative of stressed stems in an unstressed vowel; declension of (étot) and (tot); relative pronoun.

24. Review of past masc. and fem.; past plural; perfective aspect in infinitive and past; perfective future.

25. Change in 1.s. pres. of type otvetit'; order of tenses in indirect discourse; particle li in indirect questions;

26. nom. pl. in -y (i) of masc. + fem. nouns; nom. pl. of adjs.; fem. pl. of masc. in plain paired cons., /c/, or /j/; gen. pl. of adjs.

27. g. pl. of masc. in /č,ž,š,/ or sharp consonant; gen. pl. fem. in velar, plain paired cons., /c/ or palatal; g. pl. of nouns in /ija/; g pl. of nouns in cons. + ka.

28. Grammatical terms, i nom. + gen. plural of /etot/;

29. 2, 3, 4 with gen. sing. of nouns and gen. pl. of adjs.; 5-10 with gen. pl. of both nom. pl. of neuters in plain

30. paired cons. stress shifts; neuter gen. pl. of same neuters; nom. and gen. pl. of neuters in (ijo).

A manual and coding scheme for the lesson programmers have been compiled. Three lesson programmers have been trained and are currently generating the actual texts of the sessions from the outlines. Thirty sessions have already been written and eight of these have been entered, corrected, and run through the first processer, as described in the next paragraph. These lessons are ready for recording on tapes and testing on subjects. The remaining 12 lessons are being entered and corrected.

Two programs have been written to process the text written by the lesson programmers. The first operates on the code symbols used by the lesson programmers to convert the coded text to a complete text of the session consisting of a series of audio and teletype messages

to the student and the typed responses he is to make. This text will serve as a script for the recording of audio messages. The second program converts the output of the first to machine language instructions used by the computer itself. Only the first program is debugged, but the second will be ready by the time the audio equipment is received.

As soon as the first of the above-mentioned Ampex tape recorders is received, recording of the lessons will begin. Student copies will be made from the original master tape. The testing of the first lessons with pilot subjects will begin immediately thereafter and continue for a final check of the material, programs, and hardware.

Students will receive the same quarter-final exam as given to students in the conventional course, so that direct comparisons of effectiveness can be made.

II. Russian speech comprehension experiment.

Our ten pilot subjects were Stanford graduate students, one with and nine without knowledge of Russian. All ten were well acquainted with the concepts and mechanics of computer-based instruction. The comments of these sophisticated subjects, gained from questionnaires administered after each experimental session, along with our own observations and data analysis, allowed us to make substantial revisions and improvements both in experimental material and computer program.

Following these changes, the experiment proper began with undergraduate students who had no knowledge of Russian as subjects. We plan to run a total of forty subjects. Thirteen have already been run.

The equipment used was a PDP-1 computer, Philco READ displays and keyboards, CRT visual displays with light pen, and Westinghouse audio units (Prodac-50).

All Russian words and sentences are presented aurally. English translations of the Russian words are presented either aurally or aurally and visually. English translations of Russian sentences are presented visually only. Thus no knowledge of the Cyrillic alphabet is required within the context of this experiment.

The experiment consists of 388 items. These items are presented in two one-hour sessions on consecutive days. Subjects are run individually. Throughout the experiment, vocabulary is introduced by means of two methods: through the paired aural presentation of a Russian word with its translation and through context in such a way that the correct translation is logically necessary.

The items are of varying complexity ranging from aural presentation of a single Russian word with or without its English translation, to items requiring the subject to make a judgment as to the truth value

of a Russian statement relative to another Russian statement which is assumed to be true. In all cases in which the subject is required to choose between several English alternatives, the correct answer is indicated to the subject by an arrow, as soon as he has made his response. The subject is always presented with sufficient information to choose the correct response for any item at the time of the item's presentation.

III. Sources of difficulty in learning foreign-English vocabulary pairs.

The preliminary phase consisted in running an experiment to determine relatively easy and relatively difficult Japanese-English vocabulary pairs. Then, for the reasons already described, the stimulus words from the difficult (easy) pairs were paired with the response words from the easy (difficult) pairs. This new set of S-R pairs was presented to a new set of subjects under conditions identical to those under which the original pair presentations were given.

RESULTS AND DISCUSSION

I. Computer-based Russian course.

Pilot subjects will be run beginning within the next month, but to date no data have been collected.

II. Russian speech comprehension experiment.

The responses to 150 of the multiple-choice items of the subject will be analyzed. These items are the same for all subjects and are representative of the range of difficulty present in the experiment. These 150 items are interspersed throughout the two experimental sessions in sequences of 10, with different randomizations within each group of 10 for each subject. Factors that will be examined include: stimulus sentence length, number of prior training trials on the sentence and on the multiple-choice response alternatives, syntactic complexity of the sentence, position and function of the test word in the sentence, phonetic difficulty of the sentence and of the response alternatives, as well as numerous other variables. Indices of syntactic complexity, phonetic difficulty,and the like are now being formulated.

The computer program has been written to implement this data analysis. In addition to programming the sequence of trials, the program prints out the following information:

1. Number of errors per subject per lesson.
2. For each subject and item, the response made and response latency.
3. Mean over subjects of the latency per item.
4. For each item, total number of subjects who choose response alternative number 1. Similarly, total numbers who choose response 2, response 3, as well as total who failed to respond within the allotted time interval.

5. Total number of subjects who completed lesson 1, and similarly for lesson 2, etc.

Processing of these data is expected to begin soon.

III. Sources of difficulty in learning foreign-English vocabulary pairs.

It was predicted that:

1. Ease of learning would be weighted primarily on part of speech of English response (concrete nouns and adjectives being easy; verbs, adverbs, conjunctions, etc. being hard).

2. There should be no difference in learning performance between the reverse-pair group and the dictionary-pair group.

The basis for these predictions are discussed in detail in earlier progress reports.

Table 1 here

The first prediction was confirmed. A rough estimate of the extent of confirmation can be gathered from Table 1. The second prediction was not confirmed. The mean number of pairs learned (correct responses anticipated) on trial 6 for dictionary-pair group was 33.6 (out of 50). The mean number of correctly recalled pairs for the reverse-pair was 28.7. For 10 subjects responding to 50 items over 6 trials this difference is highly significant; p=.0001.

A hypothesis had been developed to account for a similar decrement observed between the Russian dictionary-pair: reverse-pair means. This hypothesis, based on pronunciation difficulty of the stimulus items, yielded the incorrect "no difference" prediction for the Japanese reverse-pair condition. It is not clear why the reverse-pair condition showed such a decrement in pair-learning.

There is a peripheral observation on this decrement supporting the first hypothesis. Namely, for those 12 Japanese stimuli showing a greater than 50 percent decrement in learning when paired with a reverse-pair response than with a dictionary-pair response, the dictionary responses were in all but two cases a noun or adjective and the reverse-pair responses were in all cases but two a verb or "other." A further experiment is planned in an attempt to shed some light on the reason for this Japanese reverse-pair decrement.

CONCLUSIONS AND IMPLICATIONS

Obviously no data conclusions can yet be drawn from the programmed instruction project, because data are not yet available. For the most part, the "Results" realized so far are a set of computer programs rather than responses from subjects. However, conclusions about

Table 1

Ease of Japanese-English Pair-learning
as a function of English response part of speech.

	Dictionary-Pair		Reverse-Pair	
	*Easiest 25	Hardest 25	Easiest 25	Hardest 25
Concrete nouns	14	2	12	4
Adjectives	7	2	7	2
Other nouns	3	6	3	6
Verbs	0	10	1	9
Other	1	5	2	4

N = 20

*Most correct total responses over 6 trials of 50 items.

methodological problems can be stated. Progress to date assures us that a computer-based Russian course can be devloped which will teach vocabulary and grammar to naive subjects. Staff-member skills used in program development included understanding of psychological principles of programming, a knowledge of descriptive linguistic facts of Russian, prior experience in conventional methods of teaching Russian, and technical mastery of FORTRAN and machine languages.

Likewise, no data conclusions are yet possible for the investigation of Russian speech comprehension. However, we may conclude that numerous surface-structure properties of Russian sentences can be quantified, thereby allowing them to be included in a regression analysis of sources of difficulty in comprehension. Finally, the Japanese-English paired associate experiment supports the conclusion that authentic (dictionary translation) pairs are easier to learn than pseudo-pairs which have been equated for pronounciability, form-class, etc. with the dictionary pairs. Evidently either phonetic symbolism or transfer from English is responsible for this effect. It was also concluded that form-class of the English response member influences difficulty in the expected direction. That is, nouns were easiest and verbs were most difficult.

SUMMARY

Top priority during the project year was given to developing a computer-based first year course in Russian vocabulary and grammar. Beginning in September 1967, the program will provide instruction for two sections of the Stanford University course in Introductory Russian. To permit evaluation of the program, the final exams will be the same for the computer-based course as for the conventional course. Successful program development requires some familiarity with psychological principles of programmed instruction, knowledge of conclusions from our experiments on learning Russian (conducted in earlier project years), knowledge of linguistic properties of Russian, prior experience in teaching the language, and expertise in writing programs. These skills were furnished by pooling the capabilities of the psychologist, linguist-language teacher, native Russian informant, and programmers on the project. Thirty-four of the planned 100 lessons have already been outlined, and the first ten of these outlines have been elaborated as complete machine-language programs. Now that the programmers have been trained, it is anticipated that outlining and writing will proceed at an accelerating pace. Teletypes have been installed, and tape recorders will be installed soon.

An experiment currently being conducted seeks to isolate the factors that affect ease of learning to comprehend spoken Russian. About half of the planned number of subjects have been run, using PDP-1 supplemented with video and audio units. Comprehension is measured first by asking the subject to translate the Russian word, phrase or sentence, and on a more advanced level by asking him questions about the Russian passage that he just heard. Factors to be examined

include various measures of complexity (e.g., sentence length, grammatical features, similarity of multiple-choice alternatives) as well as pronounciability indices derived from a phonetic analysis. The psychological contribution of each factor will be measured by a previously developed regression analysis.

Of secondary interest is a study of sources of difficulty in learning Japanese-English vocabulary pairs. Results confirmed most of the earlier findings from our Russian-English vocabulary pair experiment and enabled us to specify, at least for paired-associate learning, what it is about a foreign-English vocabulary item that makes the item easy or difficult to learn.

APPENDIX I: INSTRUCTIONS FOR LESSON PROGRAMMERS

Raw Materials.

You will receive lists containing the words which have been introduced in the course up to the lesson which you are to program. In addition to cumulative vocabulary lists you will receive separate lists covering those vocabulary items which were introduced in the preceding five lessons. Items in these lists should receive particularly frequent reinforcement in the sentences which you generate. You will also receive a list of those grammatical constructions which have been introduced up to the lesson which you are to program. Once again, the main list will be accompanied by a supplementary list indicating which items were introduced in the preceding five lessons. Since it is one of the purposes of this course to provide constant reinforcement of previously learned language behavior, you should always have the proper vocabulary and grammar lists before attempting to program a new lesson.

The material to be introduced in the new lesson will be given to you in a semi-programmed form. This means that you will not only receive a list of vocabulary items and grammatical rules to be introduced in the lesson, but also a tentative outline, showing you the order in which words and rules are to be introduced. It is a basic premise of the work on this course that the introduction of vocabulary items should serve either to illustrate or to reinforce the grammatical rules presented in a given lesson. This means that, for instance, if you are to introduce a rule on the dative singular of nouns ending in a consonant, it would be appropriate to follow this rule by the introduction of any new nouns ending in a consonant included in the vocabulary for the given lesson (and not, for instance, by a verb or an adjective). It goes without saying that no grammatical rules should be introduced until at least one vocabulary item which illustrates the rules has previously been learned by the students.

While the selection and sequencing of words and rules will be decided upon before the material is passed on to you, please feel free to advance any suggestions you may have concerning more effective ways of attaining the goals of the given lesson. If you feel, for instance, that different vocabulary items would serve to illustrate or reinforce the rules in question more effectively I will be glad to hear your suggestions. Please make such suggestions as soon as possible, however, since we cannot make major changes in the program sequence once succeeding portions of the program have been written.

Programming of vocabulary items.

The learning of vocabulary items can be divided into two fairly distinct parts: introduction and reinforcement. The introduction of a word may be accomplished in a number of ways. Bearing in mind that it is of vital importance that our students hear Russian words quite

often and that any particularly troublesome pronunciation details be brought to their attention and drilled at least briefly in the course of the program itself, you may choose to follow one of the following patterns. The most direct approach to the introduction of items is first of all to instruct the student to listen to the word. This can then be followed with an instruction to observe how the word is typed. If the "listen-observe" sequence is followed, the student has heard the Russian word four times before he sees the graphic representation. This is desirable, at least in the early stages of the program, in order to prevent a bias based on the student's knowledge of English graphemes.

Once the student has made reasonable progress in dealing with Russian sounds (and you may assume that such progress has been made by the time he reaches any of the lessons which you are to program) it is desirable that he complete the typing of the Russian word instead of simply observing it. For this purpose one should select an unambiguous sound for the student to type, probably a stressed vowel, although clearly distinguishable consonants may also be used. Never have the student attempt to fill in items which are ambiguous, for instance, unstressed vowels other than u (or i after plain consonants).

Note that whether the graphic representation is introduced by an "observe" instruction or by a "fill-in" instruction, the stressed vowel must always be indicated. If the student is to fill in the stressed vowel it is better to have him simply fill in the vowel letter, but not the stress mark. This is possible since our stress mark follows the stressed vowel instead of being located over it.

Once the item has been introduced in its graphic form it is perhaps most appropriate to proceed to any pronunciation details which require the student's particular attention. Thus, for instance, after the student has typed or observed the typing of the word "husband," you should draw his attention to the fact that in this word the final letter has a different pronunciation from the pronunciation in the word for "wife" or "woman." Comments on pronunciation details can be followed either by contrasting pronunciation of the English and Russian articulation of the item or simply by an instruction to repeat the item after the speaker. If a contrasting instruction is used, it should itself be followed by a repeat instruction.

The next step is the introduction of the meaning of the word. This can be done simply by telling the student that the word X has the meaning Y. This is accomplished by using the EQ coding. On the other hand, it is preferable to introduce meanings in context and to allow the student to guess the meaning of a given item from an example of its usage in a sentence. Such a technique is particularly easy to apply when the item introduced has a corresponding "opposite" in the student's previously acquired vocabulary. However, even when an opposed item is lacking it is possible to elicit a correct guess simply

by using the item in a situation which is typical of and more or less restricted to words of its general semantic class. Thus, it is quite possible to introduce the meaning of "book" by using it in the sentence, "He is reading a book," and allowing the student to choose between the meanings "wheelbarrow,""book," and "microphone." In general, it is desirable to have the student taking an active part in the course wherever possible, so that the selection of alternative meanings should be used frequently.

Vocabulary items which do not in themselves present new pronunciation difficulties may be introduced without the use of the "listen" instruction. When the meaning of the vocabulary item is to be guessed by the student from context, it is possible to introduce the item in a typed sentence by the use of the read-the-sentence-after-me instruction. Minor pronunciation points and points with which the student is already familiar should be noted or reinforced after the meaning of the word has been guessed. Thus, for instance, if one wishes to introduce the Russian word for "rich" to a student who already knows the word for "poor," the sequencing might be as follows. First of all the student would be told to read the question "Is he a poor man?" aloud. Then he would be told to read the sentence "No, he is a rich man" after the speaker. He would then be instructed to select the correct meaning of the word "rich." Thereafter he might be told to remember that unstressed Russian o is pronounced like unstressed a. Next, he might be told to repeat the correct pronunciation of the word "rich." The programming sequence would hereafter be the same as for words introduced by a "listen" instruction.

The introduction of the meaning of the Russian word completes the introduction of the vocabulary item. The next step in the programming of this item consists in its reinforcement.

A conservative and, until further notice, highly recommendable approach to the reinforcement of the graphic form of a given item consists in the use of the "type-the Russian-words-you-hear" instruction. The student types a number of Russian words one by one and is then given their English meaning by the teletype. Another way of achieving the same goal is to use a "type-the-sentence-you-hear" instruction. In any case, it is highly important that the student both see and hear the new vocabulary item several times in the part of the program which immediately follows its introduction.

After a "type" instruction has been carried out, the student may be told to say a Russian sentence containing the new word. This is done by the "say-in-Russian" instruction. It should be noted that the contents of the sentence can consist to a large extent of words which the student has typed separately in a preceding "type-the-word-you-hear" instruction. In any case, the sentence to be said aloud should be kept relatively simple so as to facilitate the student's concentrating his attention on the new vocabulary item.

Once a number of inflectional forms has been acquired, it is possible to reinforce a given vocabulary item by using it in a set of sentences to be completed by the student. Each of the sentences to be completed may contain the new vocabulary item in a different form. This approach serves both to reinforce the student's knowledge of the vocabulary item and to test and reinforce his knowledge of the appropriate grammatical endings to be used with the item.

A final step in the reinforcement of a vocabulary item is its integration into a more extensive text, such as a paragraph. The item need only to be used once or twice in the paragraph which may consist of as many as four or five relatively short sentences. The student should be told to listen to the paragraph. Thereafter he should be told to type or say one, two, or three-word answers to a number of questions about the paragraph. It is highly desirable that his response include the new vocabulary item at least once. In any case the new vocabulary items should be included one or more times in the questions which are asked about the paragraph.

When most or all of the above devices have been employed, the immediate reinforcement of the new vocabulary item can be considered to be accomplished. However, it is important to keep on using the vocabulary item in question fairly frequently throughout the course of the entire lesson. One criterion for the evaluation of the sequencing of vocabulary items is whether or not they allow the usage of previously introduced items in combination with items introduced at a later point in the same lesson. Thus, it would be possible to see good sequencing in the introduction of the word "what" and then the verb "to do." This allows us to use the word "what" in many of the sentences used to reinforce "to do." For example, "What is he doing?"

Presentation of grammatical rules.

The fundamental requirement governing the presentation of grammatical material is that no rule be presented which cannot be illustrated by the material which is already in the student's possession. Thus, for instance, it is ridiculous to give a complete statement on the various endings for the dative case to a student who has a knowledge only of Russian nouns ending in the vowel a. Since the material you will receive is sequenced with the primary requirement in mind, you should not often be concerned with this particular problem. Another matter which is more or less taken care of by the sequencing of the material is the requirement that each distinct rule receive a fair amount of reinforcement before a new rule is introduced. This is particularly important when different endings for one and the same grammatical category are being treated in the course of a single lesson. For instance, it is handy to introduce all of the prepositional endings for adjectives and for masculine and feminine nouns in one and the same lesson. However, it would not do to give the three different endings concerned (essentially om, e, and oj) at one and the same time.

Rather, it is best to give the rule concerning the ending for nouns first, and to give the student a fair amount of drill on the use of the prepositional case of nouns alone. Thereupon it is possible to give the rule concerning the prepositional ending of either feminine or masculine adjectives, but not of both at the same time. Only after a reasonable amount of reinforcement has been given in the use of one or the other adjectival ending should the second adjectival ending be presented to the student.

As was pointed out above, the sequencing of the material with which you will be provided should to a certain extent take care of the problem of the reinforcement of the individual rules. Thus, in all probability, if you were to program a lesson on the prepositional singular you would probably receive a set of vocabulary items and grammatical rules similar to the following one. 1) "the preposition o "about;" 2) "the prepositional singular ending for the nouns that you know is e; 3) the noun pesn> "song;" 4) the noun qena "wife;" 5) "the prepositional singular of feminine adjectives is identical with the genitive singular;" 6) the adjective interesnyj "interesting;" 7) the adjective neinteresnyj "boring;" 8) "the masculine prepositional ending of adjectives is om." The introduction of new nouns after the rule for the prepositional endings of nouns and of new adjectives after the rule for the feminine prepositional ending of adjectives would of course indicate to the programmer that the reinforcement of these rules should precede the introduction of the remaining rules. However, even if no new vocabulary items were given, the requirement would be the same.

A third requirement in the proper programming of grammatical material is that rules previously introduced, either in the course of the same lesson or in preceding lessons (particularly the last three preceding lessons), should receive a fair amount of reinforcement even in material primarily designed to reinforce rules which have just been introduced. This can be accomplished by using sentences illustrating previously introduced rules as the framework in which the student actively operates on material reinforcing the most recently introduced rules. Thus, for example, a student who at the beginning of a given lesson learned the ending of the first person singular present tense piwu "I write" could receive reinforcement of a later rule on the prepositional singular of nouns by completing sentences of the type "I am writing about X," in which X is the noun the ending of which the student is to fill in.

In general a good rule to follow in the reinforcement of grammatical material is that the most immediate reinforcement should be of a fairly simply nature. Thus, the first exercise the student might be given upon learning the prepositional singular of nouns might consist simply of filling in a set of prepositional phrases of the type "in X" or "about Y." Again, he might be told simply to say in Russian "about the man" or "in the house." After this initial reinforcement of the

rule within simple frameworks designed to concentrate the student's attention upon the material just acquired, the reinforcement could then be shifted to frameworks which allow for the passive reinforcement of material previously acquired in the course (i.e. longer sentences or even paragraphs).

In the latter part of a given lesson, particularly after the student has had a chance to assimilate the most recently presented grammatical rules fairly thoroughly, it may be desirable to give him the opportunity to obtain active reinforcement of all of the grammatical material presented up to the given point in the lesson. This can be accomplished in a relatively economical fashion by using a "type-the-necessary-characters-each-time-the-teletype-pauses" instruction, which allows the programmer to call for a number of fill-in responses in the course of a single Russian sentence. The use of this instruction is, however, limited by the fact that the student cannot refer to following parts of the sentence in order to decide on the response which he is to make. This means that responses which would be perfectly unambiguous were the student to make them after he had seen the entire sentence-frame may have to be avoided because of their potential ambiguity. However this may be, it is important not to forget that even though an item was introduced relatively far back in the lesson, it should be actively reinforced to some extent all the way to the end.

At the conclusion of the lesson it is desirable to give a complete review drill on all of the grammatical material presented in the entire lesson. There are no special instructions for this purpose. One can employ the same devices as before, merely making sure to include the active reinforcement of all the material covered in the lesson. The grammatical review drill should be followed by a vocabulary test in which the student is called upon to type the Russian equivalents of the vocabulary items which were introduced throughout the course of the lesson.

APPENDIX II

Lesson 1:

Definition: stressed and unstressed vowels.
In Russian the indefinite article and the present of to be are not said.
A sentence ends with a period.
A declarative sentence can be made interrogative by raising the voice at the end.
pronunciation of -a and -o
there is no definite article in Russian
pronunciation of -i
pronunciation of t
pronunciation of]
unstressed o = unstressed a
pronunciation of u

Lesson 2:

pronunciation of k
pronunciation of r
pronunciation of b
pronunciation of l
nouns and pronouns in -a take a past tense in -a
pronunciation of palatalized l
pronunciation of g
pronunciation of n
pronunciation of palatalized n
pronunciation of palatalized a.

Lesson 3:

pronunciation of s
pronunciation of palatalized t
pronunciation of palatalized l
pronunciation of palatalized b
direct object form of nouns in -a, replaces -a by -u, and thus those in - > by <.
Definition: palatalized consonants and nonpalatalized consonants.
aou] indicate that the preceding consonant is nonpalatalized; > < e indicate that it is palatalized.
i also indicates that the preceding consonant is palatalized.
; means that the preceding consonant is palatalized.
an infinitive regularly ends in -t;.
before nouns in -a, vaw = vawa.
pronunciation of palatalized -s and unstressed -e- before nouns in -a naw = nawa.

Lesson 4:

pronunciation of i after w (y)
pronunciation of g
consonants nonpalatalized before -y.
after vy present tense form adds -e to end of form used for on, ona...
nawv and vawv = direct object forms of nawa and vawa.
after my present tense form replaces -t at the end of the form used after on... by -m.

Lesson 5:

pronunciation of j
j + a = ⩽
pronunciation of z
j + u = ⩾
pronunciation of n
j + o = ←
j +] = e
e ← does not change before direct objects
unstressed -e pronounced like unstressed i.
j + i = i
b; + j + o = b; ←
pronunciation of h
"whose X is this?" = "hej]to X?"

Lesson 6:

j + a = ⩾
after ⩾ present tense form replaces -it, -im, -ite by -u.
pronunciation of x
-i + u = ⩽, so poj- & znaj- + u = po⩽ and zna⩽.
in verbs such as rabotat;, drop -t;, and add -et
for present tense form after on.
nouns ending in a consonant which denote animate beings add -a for direct object form.
adjectives such as molodoj and staryj replace -oj and -yj by -a⩾ before nouns in -a.
pronunciation of ÷
adjectives such as molodoj and staryj replace -oj and -yj by -u⩽ before direct object forms in-u.

Lesson 7:

b;⩽ from b;⩾t
-g- in kogo pronounced -v-
noun in a consonant +a placed after another noun denotes possession
vawego and nawego = direct object forms of vaw and naw used with animate nouns in a consonant
pronunciation of c
moego = direct object form of moj used with animate nouns ending in a consonant
direct object form of adjective used with animate noun ending in consonant replaces -oj/yj by -ogo
-g at end of a word pronounced -w
-g at end of a word pronounced -k
po⩽ from po⩾t
govor ⩽ from govorit
pomn ⩽ from pomnit
direct object ego, like e⩾ stands before the verb
ego remains unchanged before nouns in -a

Lesson 8:

vas and nas = direct object forms of vy and my
after a double subject, the present tense form rabota⩽t is used for verbs having the form rabotaet
the possessive of nouns in -a preceded by a non-palatalized consonant, replaces -a by -y
when the -a of the basic form follows -j or a palatalized consonant, the ending is written -i
the adjectives used with possessives in -y/i, replace the -go of vashego, bogatogo... by j
no indicates that what follows is unusual or unexpected
men⩾ = direct object of ⩾
verbs having present tense forms in -it, replace -it by -at after a plural subject, such as oni
if the final consonant of the stem is palatalized, such a form is written -⩾t.
sto⩾t from sto⩾
before the present tense ending -u, verbs with forms in -dit replace -d by -q

Lesson 9:

direct object form of nouns in palatalized consonant replaces ; by ⩾
u+ possessive + thing possessed = ___has_____
kogo used for kto after u
nas, vas, men⩾ used for my, vy, ⩾ after u
nego, ne⩾ used for on, ona after u
ix = direct object form of oni
nix used for oni after u

The possessive form of nouns ending in -ka, ga, xa replaces -a with -i, and k-, g-, x- are palatalized.

u + possessive of x + net + y = x does not have y

kakoj + possessive of x + y? = what sort of y does x have?

Lesson 10:

oni piwut, because w is non-palatalized.

nouns ending in a consonant which denote inanimate beings have a direct object form identical to their vasic form.

direct object form of adjective used with inanimate noun ending in consonant identical to basic form

after preposition -o, nouns ending in consonant or -a take the ending -e, that is,] with palatalization of preceding p, b, f, v, m, t, d, s, z, n, r, l, k, g, x

nouns whose last stem consonant is palatalized have same ending after o as above

after o, kom used for kto

before word beginning with a vowel, o written ob

after o, adjectives with nouns ending in consonant take -om

after o, adjectives with nouns ending in -a have same form as possessive (-oj)

after o, otec = otce

c remains nonpalatalized before e(as do w, q)

nawem, vawem from vawego, nawego

piwet but piwy

after o, use h←m for hto

after v, use same endings as after o

in qivu, qivut, v nonpalatalized, therefore endings written -u, -ut

qiv←m, qiv←te, qiv t: v palatalized

after o or v, moj written mo←m with nouns ending in a consonant

Lesson 11:

after o, my, vy take forms nas, vas

after o, on takes form n←m

call forms after o, v, prepositional

after o, ona takes form nej

na takes prepositional

voiced consonants (v, b, z, d, q, g) become voiceless before voiceless consonants (f, p, s, t, w, h, c, k, x), including across preposition boundary

verbs with present forms in -it, -im, -ite, and a stem in a labial (p, b, f, v, m), add -l≤ for ≥ form

l≤bit, but l≤bl≤' (same as piwet, piwu)

nix is prepositional of oni

mne is prepositional of ≥

before mne, o has form obo

Lesson 12:

svoj vs. ego/ e←/ ix
many verbs with -⩾t for oni form, have -it; in infinitive
most verbs so far = -at; a⩽t or -it; ⩾t.
-at;, a⩽t has -aet with on. -it; -⩾t has -it.
⩾ form always stresses same syllable as infinitive, all other forms follow stress of oni form
x toqe ne y = x doesn't y either

Lesson 13:

"-om" after "zas"= instrumental
"i" becomes "y" in "s Ivanom
"ym" = instrumental singular masculine adjectives
"em" = instrumental of masculine nouns in -;

Lesson 14:

after -k-, the initial -y- of ending by i-
-s-+-q- pronounced as long q
nawia/vawi = instrumental of naw/vaw
before a word beginning with s + another consonant, preposition s written so.
-j + y is replaced by i
pered takes instrumental
bol;noj can be used as a noun
instrumental for feminine nouns in -a is -oj
instrumental for adjectives with feminine nouns is -oj (same as for prepositional and genitive)
before a word beginning with z + another consonant preposition s written so

Lesson 15:

instrumental of nouns in -⩾ is-ej.
conjunction a adds information in contrast to what has already been said
no used when a possible shows that the statement is contrary to expectations
sh pronounced ÷
consider x to be y = shitat; x(d.o.) y(inst.)
nouns ending in stressed -⩾ form the instrumental in-←j.
if stress of a masculine noun shifts between nominative and genitive, the change remains in the other cases
masculine nouns ending in -; with stressed endings, have an instrumental in - ←m
pravit; takes instrumental
prepositional in nouns in -i⩾ is -ii

Lesson 16:

amerikanec drops -e- in declined forms
nouns ending in -c, h, q, w, ÷ with unstressed ending has instrumental in -em.
after ÷ have -a, not ь, although ÷ is a palatalized consonant, because it is unpaired
braun and wmit declined like regular Russian nouns in a consonant
-u, not -ъ after -h- and ÷
ogo, -om, and -oj are replaced by -ego, -em, and -ej if unstressed after c, h, q, w, ÷
foreign names not declined when they refer to women
of the consonants g, k, x, c, q, w, h, ÷, only c may be followed by y

Lesson 17:

instrumental of my = nami
instrumental of vy = vami
with/together with = s + instrumental
with/ by means of = instrumental alone
hem is instrumental of hto
after byt;, predicate noun in instrumental
What do you want to be? = Kem by xotite byt;?
im = instrumental of on
im after preposition = nim
ej = instrumental of ona
ej after preposition = nej
after ь, past form is masculine if it refers to a man, feminine if it refers to a woman
predicate noun of nationality after past tense of byt; is in its basic (not Instrumental) form
imi is instrumental of oni
prepositions ending in a consonant add -o before mnoj

Lesson 18:

passive construction created by adding -sь (-tsь pronounced -tsa)
x is interested in y = x + interesuetsь + inst. of y
when not after -t-, -sь pronounced as written
after a vowel -sь loses its vowel to become -s;
kaqetsь takes instrumental
he will have _____ = u nego budet _____
budet takes instrumental predicate
budet + infinitive = future tense
-t; sь pronounced same as -tsь (which = -tsa)

Lesson 19:

hard sign (cons. followed by /j/)
'dative case of nouns
impersonal kaqets ⩾with dative 'it seems to x'.
(gotovit;)'k plus dative'
dative masculine + feminine of adjectives
po+dative
uhit;s⩾

Lesson 20:

ПОМОГАТЬ _ ДАТ
НАМ, ВАМ
ЕМУ, К НЕМУ
ЦИ КАК ЦЫ
ЕЙ, К НЕЙ
ЧИАТАТЬ ЛЕКЦИЮ
ТРУДНО И Т.Д. С ИНФИНИТИВОМ
ТО ЖЕ С ДАТ. ПАД
ИМ, К НИМ
ЧЕМУ
МНЕ
ПРИСТАВАТЬ К
КО МНЕ
СР. РОД. ВИН. П. КАК ИМ. П.
ПРИЛ. СР. РОДА НА -ОЕ
ОСТАЛЬНЫЕ ФОРМЫ СР. КАК ФОРМЫ М. Р.
ЧЕГО
ОЧЕНЬ С ГЛАГОЛАМИ ЛЮБИТЬ, НЕНАВИДЕТЬ, ПОМОГАТЬ, ИНТЕРЕСОВАТЬСЯ

Lesson 21:

НАШЕ, ВАШЕ
ХОРОШЕЕ, НАСТОЯЩЕЕ, СВЕЖЕЕ
МОЁ, СВОЁ
ЕМ, ЕСТ, ЕСТЬ
neuters in cons. plus Й
neuters in -ИЙ
ОНО like ОН
imperative of stems in - АЙ
ЩТВЕЧАТЬ plus dative

Lesson 22:

nouns in -a which denote male persons
verbs of type leqat;, slywat; spat;
hego is gen. of hto. (hego on boits⩾?)
imperative of govorit;, sidet;, leqat;, etc
imper. of smotret;, etc.

Lesson 23:

continue and complete introduction of imperative
nado + infinitive
moj, naw etc. as mine, ours
declined forms of]to and tot
masculine adjectives with noun sluga

Lesson 24:

kotoryj - drill its use and new vocabulary

Lesson 25:

past tense -l -la -li
stress of bylá, pilá, qilá
introduce perfective verbs and drill on perfective vs. imperfective usage in past, future, and imperative

Lesson 26:

continue perfective vs. imperfective
use of partitive genitive with perfective verbs

Lesson 27:

sequence of tenses - direct and indirect discourse
li constructions

Lesson 28:

nom./ acc. plural -y or -i for masculine and feminine nouns
gen. plural -ov or -ev for masculine nouns
nom./ acc. plural -ye or -ie for adjectives
gen. plural -yx or ix for adjectives
neskol;ko, nemnogo, mnoga + gen. pl.

Lesson 29:

gen plural -ej for masculine nouns in h, w, q,÷;
gen pl. zero ending for fems.
insert of -o- if noun ends in -ka (-e- if unstressed after h, w, q,÷ gen. plural of i⩾ nouns.

Lesson 30:

This lesson introduces no new grammar, but contains words to be used in formulating review statements and future rules

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Top priority was given to developing a computer-based first year course in Russian vocabulary and grammar, which will be introduced at Stanford in September 1967. The final exam will be the same for the computer-based sections as for the conventional sections. The program is being produced through the joint efforts of the psychologist, linguist-language teacher, native Russian informant, and computer programmer on the project. Thirty-four of the planned one-hundred lessons have been prepared. Installation of teletypes and tape recorders is in progress.

Also, an experiment is being run to determine the factors that influence ease of learning to comprehend Russian speech. Comprehension is measured either by asking the student to translate the utterance he heard, or to answer questions based on it. Analyses will seek to relate the proportion of errors to syntactic and phonetic properties of the speech, using regression techniques. Finally, a study involving learning of Japanese-English vocabulary pairs enabled us to specify some of the linguistic determinants of difficulty in learning word-for-word translations.

16. RETRIEVAL TERMS (Continue on reverse)

computer-based second-language instruction
learning of Russian vocabulary plus grammar
sources of difficulty in foreign speech comprehension
learning of foreign-English vocabulary pairs

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